Automatic Control A

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Name:..

University ID number:...............................

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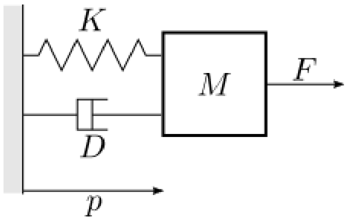
Warnings:

- This file consists of **8** pages (including cover). All the pages should be signed.
- During the exam you are not allowed to exit the room for any other reason than handing your work or withdrawing from the exam.
- You are not allowed to withdraw from the exam during the first 30 minutes.
- During the exam you are not allowed to consult books or any kind of notes.
- You are not allowed to use calculators with graphic display.
- Solutions and answers can be given **either in English or in Italian**.
- Solutions and answers must be given **exclusively in the reserved space**. Only in the case of corrections, or if the space is not sufficient, use the back of the front cover.
- The clarity and the order of the answers will be considered in the evaluation.
- At the end of the test you have to **hand this file only**. Every other sheet you may hand will not be taken into consideration.

Use this page ONLY in case of corrections or if the space reserved for some answers turned out to be insufficient

Exercise 1

Consider the following mechanical system (mass-spring-damper)

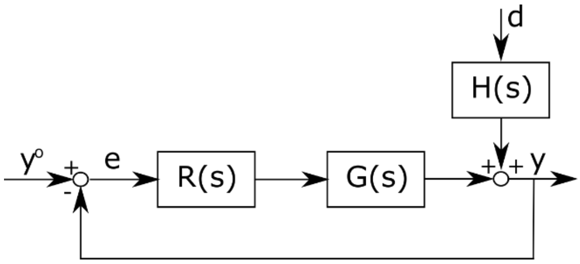


1.1 Selecting force F as input and velocity v as output, write the equations of the dynamical system that models the mass-spring-damper.

1.2 Assume $M > 0$, $D > 0$, and $K > 0$. Is the system completely controllable and completely observable?

Exercise 2

Consider the following control system



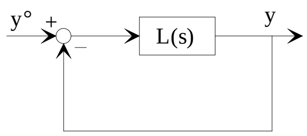
where $G(s) = 10\dfrac{1+0.1s}{s(1+s)}$ and $H(s) = \dfrac{1+s}{1+0.2s}$.

Compute the transfer function $R(s)$ of a regulator in such a way that:

- $|e_\infty| \leq 0.015$ for $y°(t) = 10$ sca(t) and $d(t)$ = ram(t);
- the phase margin φ_m is greater or equal to 70°;
- the crossover frequency ω_c is greater or equal to 10 *rad/s*.

Exercise 3

Consider the following closed-loop system



where $L(s) = \rho \dfrac{s-4}{s(s+2)^2}$.

3.1 Sketch the direct and inverse root loci.

3.2 Using the previous root loci, find the values of ρ for which the closed-loop system is asymptotically stable.

Exercise 4

Consider the following discrete time dynamical system

$$G(z) = \frac{10}{z^2 + 5z + 6}.$$

4.1 Compute the analytic expression of the response of the system to the input $u(k) = 4^k$, $k \geq 0$.

4.2 Compute the initial value of the response using the analytical expression determined at the previous step, and compare it with the result obtained using the initial value theorem.

4.3 Compute, if possible, the final value of the response determined at the previous step using the final value theorem.

Exercise 5

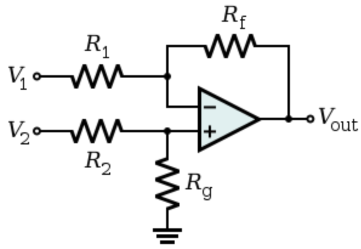
5.1 Consider the P/PI (position/velocity) control of a servomechanism, including velocity feedforward. Show that this control architecture is equivalent to a PID, determining the relations between the P/PI and PID parameters.

5.2 Assuming that the servomechanism is elastic and it is characterized by $J_m = 0.02\ Kgm^2$, $\rho = 2$, $K_{el} = 2000\ Nm/rad$, design a PI velocity controller.

5.3 Find a suitable sampling time for the digital implementation of the previous regulator and determine the controller transfer function using Tustin method.

Exercise 6

6.1 Compute the input-output relation that describes the following circuit



6.2 Determine the values of the resistors so that the previous circuit acts as a differential amplifier with gain equal to 10.

6.3 Explain the differences between single-ended and differential signaling, highlighting pros and cons of each methodology.